VERIFICATION OF TRANSLATION

I, Kwang-Won Lee of 114-dong 1103-ho, Hwanggoljugong APT., Yeongtong-dong, Paldal-gu, Suwon-si, Gyeonggi-do, Republic of Korea, declare that I have a thorough knowledge of the Korean and English languages, and the writings contained in the following pages are correct English translation of the specification and claims of Korean Patent Application No. 1999-0065038.

This 12th day of July, 2004

By: ____________________

Kwang-Won Lee

KOREAN INDUSTRIAL PROPERTY OFFICE

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Applicant(s) : **LG. Philips LCD Co., Ltd.**

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[TITLE OF INVENTION IN KOREAN] 액정 표시장치

[TITLE OF INVENTION IN ENGLISH] Liquid Crystal Display Device

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[PURPORT] We submit application as above under the article 42 of the Patent Act.

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[FEES]

[BASIC APPLICATION FEE]	13 page(s)	29,000	Won
[ADDITIONAL APPLICATION FEE]	1 page(s)	1,000	Won
[PRIORITY FEE]	0 thing(s)	0	Won
[EXAMINATION REQUEST FEE]	0 claim(s)	0	Won
[TOTAL]		30,000	Won

[ENCLOSED] 1. Abstract, Specifications (with Drawings)_1 set

[SPECIFICATIONS]

[NAME OF INVENTION]

Liquid crystal display device

[BRIEF EXPLANATION OF FIGURES]

FIG. 1 is a cross-sectional view illustrating a pixel of a liquid crystal display device according to the related art;

FIGS. 2A and 2B illustrate the operation of a conventional TN-LCD panel;

FIG. 3 is a cross-sectional view illustrating a pixel of a conventional IPS-LCD device;

FIGS. 4A and 4B illustrate the operation of the conventional IPS-LCD device of FIG. 3;

FIG. 5 is a graph of a color coordinate property with respect to various viewing angles of the conventional IPS-LCD device;

FIG. 6 shows an alignment structure of a FLC and illustrates the operation thereof;

FIG. 7 is a cross sectional view illustrating a LCD panel according to an embodiment of the present invention;

FIG. 8 is a cross sectional view illustrating an electric field applied to the LCD device of FIG. 7;

FIG. 9 is a graph illustrating a color coordinate property with respect to various viewing angles in an LCD device according to an embodiment of the present invention;

FIG. 10A is a graph illustrating a contrast ratio with respect to the viewing angle in an LCD device according to an embodiment of the present invention; and

FIG. 10B is a graph illustrating the contrast ratio with respect to the viewing angle in a conventional IPS-LCD device.

< Explanation of major parts in the FIG.s >

50: lower substrate

52: second electrode

54: lower orientation film

60: upper substrate

62: first electrode

64: upper orientation film

70: liquid crystal layer

[DETAILED DESCRIPTION OF INVENTION]

[OBJECT OF INVENTION]

[TECHNICAL FIELD OF THE INVENTION AND PRIOR ART OF THE FIELD]

The present invention relates to liquid crystal display devices. More particularly it relates to liquid crystal displays having thin film transistors and a method of fabricating the same. Especially, the liquid crystal display device of the present invention includes a ferroelectric liquid crystal polymer orientation film.

A liquid crystal display device uses the optical anisotropy and polarization properties of liquid crystal molecules to produce an image. Liquid crystal molecules have a definite orientational alignment as a result of their long, thin shapes. That orientational alignment can be controlled by an applied electric field. In other words, as an applied electric field changes, so does the alignment of the liquid crystal molecules. Due to the optical anisotropy, the refraction of incident light depends on the orientational alignment of the liquid crystal

molecules. Thus, by properly controlling an applied electric field a desired light image can be produced.

While various types of liquid crystal display devices are known, active matrix LCDs having thin film transistors and pixel electrodes arranged in a matrix are probably the most common. This is because such active matrix LCDs can produce high quality images at reasonable cost.

FIG. 1 is a cross-sectional view illustrating a conventional twisted nematic (TN) LCD cell in an active matrix LCD. As shown, the TN-LCD cell has upper and lower substrates 2 and 4 and an interposed TN-LC layer "LC". The lower substrate 2 has a thin film transistor (TFT) "S" as a switching element that switches a voltage that changes the orientation of the LC molecules. The lower substrate 2 also includes a pixel electrode 14 that is used to apply an electric field across the LC layer "LC" in response to signals applied to the TFT "S". The upper substrate 4 has a color filter 8 for producing a color, and a common electrode 12 on the color filter 8. The common electrode 12 serves as an electrode that produces the electric field across the LC layer "LC" with the assistance of the pixel electrode 14. The pixel electrode 14 is arranged over a pixel portion "P," i.e., a display area. Further, to prevent leakage of the LC layer "LC", the two substrates 2 and 4 are sealed by a sealant 6.

As described above, since the pixel and common electrodes 14 and 12 of the conventional TN-LCD panel are positioned on the lower and upper substrates 2 and 4, respectively, the electric field induced between them is perpendicular to the lower and upper substrates 2 and 4. The described liquid crystal display device has advantages of high transmittance and a high aperture ratio. Furthermore, as the common electrode on the upper substrate acts as a ground, the liquid crystal is shielded from static electricity.

FIGS. 2A and 2B illustrate the operation of a conventional TN-LCD panel. When no electric field is applied to the LC 10, the TN-LC molecules are aligned as shown in FIG. 2A. The longitudinal axes of the TN-LC molecules gradually twist along polar angles (along a helical axis) with respect to the substrates such that the TN-LC molecules gradually rotate 90 degrees between the lower substrate and the upper substrate.

Although not exactly indicated in FIGS. 2A and 2B, first and second polarizers are positioned on the exterior surfaces of the lower and upper substrates, respectively. The longitudinal axes of the liquid crystal molecules in contact with the lower substrate align with the axis of the first polarizer that is on an exterior surface of the lower substrate. Likewise, the longitudinal axes of the liquid crystal molecules in contact with the upper substrate align with the axis of the second polarizer that is on an exterior surface of the upper substrate.

Referring now to FIG. 2B, when an electric field is applied across the liquid crystal LC 10, the TN-LC molecules align perpendicular to the upper and lower substrates. That is to say, the molecular alignment of the TN-LC is set by the perpendicular electric field such that the longitudinal axes of the TN-LC molecules tend to become parallel with the direction of the electric field. The entering light is then blocked.

A TN-LCD that operates according to the foregoing description has a serious disadvantage in that it has a narrow viewing angle. Since the TN-LC molecules are gradually rotated with a gradual change of the polar angle, the contrast ratio and brightness rapidly fluctuate with respect to the viewing angle.

Accordingly, to overcome the above-mentioned problem, an in-plane switching (IPS) LCD panel has been developed. Unlike the TN (or STN) LCD panel described above, an IPS-LCD panel uses an electric field that is parallel with the upper and lower substrates.

FIG. 3 is a cross-sectional view illustrating a pixel of a conventional IPS-LCD device. As shown in FIG. 3, lower and upper substrates 30 and 32 are spaced apart from each other, and a liquid crystal layer 10 is interposed therebetween. The lower and upper substrates 30 and 32 are often referred to as an array substrate and a color filter substrate, respectively. On the lower substrate 30 are a pixel electrode 34 and a common electrode 36. The pixel and common electrodes 34 and 36 are aligned parallel to each other. Although not shown in FIG. 3, on a surface of the upper substrate 36 is a color filter that is positioned between the pixel electrode 34 and the common electrode 36 of the lower substrate 30. A voltage applied across the pixel and common electrodes 34 and 36 produces an electric field 35 through the liquid crystal layer. The liquid crystal molecules have a negative dielectric anisotropy, and thus it aligns parallel to the electric field 35.

FIGS.4A and 4B conceptually help illustrate the operation of a conventional IPS-LCD device of FIG. 3. When no electric field is produced by the pixel and common electrodes 34 and 36 (reference FIG. 4A), the longitudinal axes of the LC molecules are parallel. On the contrary, when an electric field is produced by the pixel and common electrodes 34 and 36 (reference FIG. 4B), because the pixel and common electrodes 34 and 36 are on the lower substrate, an in-plane electric field that is parallel to the lower substrate is produced. Accordingly, the LC molecules twist to bring their longitudinal axes into coincidence with the electric field. Thus, as shown in FIG. 4B, the LC molecules align with their longitudinal axes parallel with a line perpendicular to the pixel and common electrodes 34 and 36.

In the above-mentioned IPS-LCD panel, there is no transparent electrode on the color filter. Furthermore, the liquid crystal used in the above-mentioned IPS-LCD panel has a negative dielectric anisotropy.

The IPS-LCD mode has an advantage of a wide viewing angle. Namely, when a user looks at the IPS-LCD display device a wide viewing angle of about 70 degrees in all directions (up, down, right and left) is achieved.

[TECHNICAL SUBJECT OF INVENTION]

However, since the pixel and common electrodes 34 and 36 are on the same substrate, the transmittance and aperture ratios of the above-mentioned IPS-LCD are low. In addition, the response time to a driving voltage is not optimal. Finally, the color of their images tends to depend on the viewing angle.

FIG. 5 is a graph of the CIE (Commission Internationale de l'Eclairage) color coordinates of a conventional IPS-LCD device that shows the dispersion of color. The color coordinate property of FIG. 5 is with respect to various viewing angles of the conventional IPS-LCD device. The horseshoe-shaped area is the distribution range of the wavelength of visible light. The results are measured using a standard white light source [point (0.313, 0.329) in CIE coordinates] and various viewing angles of right, left, up and down, and 45 and 135 degrees. The range of the color dispersion is so long that the white light emitted from the conventional IPS-LCD device is dispersed largely according to the viewing angle. This results from the fact that the operation of the conventional IPS-LCD device is controlled by birefringence.

To overcome the problems described above, the present invention is directed to an LCD device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art. An object of the present invention is to provide an LCD device having a low color dependence on viewing angle and a high aperture ratio.

[CONSTRUCTION AND OPERATION OF INVENTION]

In order to achieve the above object, an embodiment in accordance with the principles of the present invention provides a liquid crystal display device that includes first and second substrates facing to and spaced apart from each other; first and second electrodes formed on inner surfaces of the first and second substrates, respectively; a first orientation film on the first electrode, the first orientation film including a ferroelectric liquid crystal polymer; a second orientation film on the second substrate; first and second polarizers on exterior surfaces of the first and second substrates; and a liquid crystal layer between the first and second orientation films.

In the device, the second orientation film includes a homogeneous alignment film. The first polarizer has a polarization axis perpendicular to an alignment direction of said first orientation film. The second polarizer has a polarizing axis parallel to an alignment direction of said second orientation film.

Reference will now be made in detail to an illustrated embodiment of the present invention, an example of which is shown in the accompanying drawings.

In a conventional liquid crystal display device, orientation films are used to orientate a liquid crystal layer. Such films are typically formed by a rubbing process that is applied to a polyimide (PI) to form minute grooves in the PI. However, in the illustrated embodiment of the present invention, a ferroelectric liquid crystal polymer (FLCP) is used as an orientation film.

A FLC has characteristics of spontaneous polarization and bistability. They are capable of providing high quality images without contrast degradation or flickers. In addition, the FLC has a hundred times faster response than the TN LC or STN LC. This is due to the spontaneous polarization of the FLC. The high speed response of the FLC enables

faster responses, such as to a mouse that is used as a data input apparatus in computers and/or to window operating systems that are widely used in computers.

FIG. 6 shows an alignment structure of a FLC and illustrates the operation thereof. As shown, the longitudinal axes of FLC molecules gradually rotate to form a helical structure. Due to the helical structure, the FLC is appropriate for use in large-scale LCD devices needing wide viewing angles.

In the illustrated embodiment of the present invention, the alignment direction of the orientation film changes according to an applied electric field, thus using the electrical property of the FLC. Therefore, a liquid crystal display device having a superior optical property can be provided. That is, the FLCP controls the alignment of the liquid crystal layer according to an applied electric field.

Now, with reference to the drawings, a liquid crystal display device according to an illustrated embodiment will be explained in detail.

FIG. 7 is a cross sectional view illustrating a LCD panel according to an embodiment of the present invention. As shown in Figure 7, a lower substrate 50 having a switching device (not specifically shown, but reference the TFT in FIG. 1) is spaced apart from an upper substrate 60 that includes a color filter (again, not specifically shown, but reference FIG. 1). A liquid crystal layer 70 is disposed between the lower and upper substrates 50 and 60. Upper and lower polarizers (not shown) are positioned on exterior surfaces of the upper and lower substrates 60 and 50, respectively.

On the interior surface of the upper substrate 60 is a first electrode 62. On the first electrode 62 is an upper orientation film 64 having an FLCP layer. Further, on the interior surface of the lower substrate 50 is a second electrode 52. On the second electrode 52 is a lower orientation film 54.

The liquid crystal layer 70 can have a negative dielectric anisotropy. Alternatively, a positive dielectric anisotropy can be used for the liquid crystal layer 70. Also, a chiral dopant can be added to the liquid crystal layer 70. However, the liquid crystal layer 70 includes a twisted nematic liquid crystal layer that has a twist angle of at least 90 degrees. When an electric field that is perpendicular to the substrates is induced between the first and second electrodes 62 and 52, there is no rotational force to induce a polar angle to the molecules.

In another aspect, the upper and lower orientation films 64 and 54 have homogeneous alignments such that the LC molecules are homogeneously aligned at their early state by the orientation films.

FIG. 8 is a cross sectional view illustrating an electric field applied to the LCD device of FIG. 7. Referring now to Figure 8, when a voltage source V applies a voltage between the first and second electrodes 62 and 52 an electric field that is perpendicular to the lower and upper substrates 50 and 60 is produced. Due to that electric field, a rotational force having a plane that is parallel with the upper substrate 60 is applied to the FLCP molecules of the upper orientation film 64. Therefore, the alignment of the FLCP molecules in the upper orientation film 64 changes.

Still referring to Figure 8, at the boundary between the liquid crystal layer 70 and the upper FLCP orientation film 64, as the alignment of the FLCP molecules in the upper orientation film 64 changes, so does the alignment direction of the liquid crystal layer 70 adjacent the boundary. That is to say, when an electric field between the first and second electrodes 62 and 52 is created, the molecules of the liquid crystal layer 70 at the boundary follow the changed alignment of the FLCP molecules in the FLCP orientation film 64. The previously homogeneously aligned liquid crystal layer 70 is no longer homogeneously aligned.

Accordingly, under an applied electric field, the liquid crystal layer 70 that was homogeneously aligned without the electric field changes its alignment to have a twist.

Referring now to Figures 7 and 8, the first and second polarizer (not shown) are respectively formed with regard to the alignment direction of the upper and lower orientation films 64 and 54. For example, a transmittance axis of the first polarizer formed on the upper substrate 60 is perpendicular to the alignment direction of the upper orientation film 64, while the transmittance axis of the second polarizer formed on the lower substrate 50 is parallel with the alignment direction of the lower orientation film 54. In that case, the transmittance axis directions of the first and second polarizers are perpendicular to each other. In addition, the lower orientation film 54 may be formed with the FLCP orientation film.

Accordingly, when the liquid crystal molecules of the liquid crystal layer 70 are homogeneously aligned (no electric field), light incident on the first polarizer of the lower substrate 50 is blocked either by the first polarizer, or by the second polarizer after passing through the liquid crystal layer 70. This produces a dark state.

Further, when the liquid crystal molecules of the liquid crystal layer 70 are twisted by an electric field, the polarization of the light that passes through the first polarizer is rotated along the twist of the liquid crystal molecules such that the light passes through the second polarizer formed on the upper substrate 60. This is a white state.

In the above-mentioned operation, since the liquid crystal molecules rotate on planes parallel with the substrates, the color dependence on the viewing angle is low. Further, as there is little or no light leakage in the dark state, a high contrast ratio can be achieved.

FIG. 9 is a graph illustrating a color coordinate property with respect to various viewing angles in an LCD device according to an embodiment of the present invention. Similar to FIG. 5, the results are measured using a standard white light source and at various

viewing angles of right, left, up and down, and 45 and 135 degrees. When compared with the long dispersion range shown in FIG. 5, the range of the color dispersion in FIG. 9 is very short, almost converging to a point. The almost converged color dispersion range means that the color dispersion characteristic of the LCD device according to the principles of the present invention are superior to that of the conventional IPS-LCD device. In other words, the color dependence on the viewing angle is much improved in an LCD device according to the principles of the present invention.

Contrary to the conventional IPS-LCD device described above, the first and second electrodes (common and pixel electrodes) of an LCD device according to the principles of the present invention are formed on different substrates. This enables an improved aperture ratio.

FIG. 10A is a graph of the contrast ratio versus viewing angle of an LCD device according to the principles of the present invention, while FIG. 10B is a graph of the contrast ratio versus viewing angle of a conventional IPS-LCD device. By comparing FIGS. 10A and 10B, it can be seen that the contrast ratio versus viewing angle quality of an LCD device according to the principles of the present invention is comparable to that of the conventional IPS-LCD device, which itself has a superior viewing angle to that of a conventional TN-LCD device.

An LCD device according to the principles of the present invention and a conventional TN-LCD device have some similarities in the twist alignments of their liquid crystal layer. However, the liquid crystal molecules of an LCD device according to the principles of the present invention rotate on planes parallel with the substrates, while the liquid crystal molecules of a conventional TN-LCD device rotate along a polar angle. Therefore, an LCD device according to the principles of the present invention has low dependence on the viewing angle. In addition, since there is little or no light leakage during the non-electric field mode,

the contrast ratio of the LCD device according to the principles of the present invention is high.

It will be apparent to those skilled in the art that various modifications and variation can be made to the illustrated embodiment without departing from the spirit or scope of the invention. For example, in another embodiment the transmittance axis of the upper polarizer can be perpendicular to the alignment direction of the lower orientation film while the transmittance axis of the first polarizer can be formed parallel with the alignment of the upper FLCP orientation film. Furthermore, the lower orientation film can include an FLCP layer. Thus, it is intended that the present invention cover all modifications and variations provided they come within the broad scope of the appended claims and their equivalents.

[EFFECT OF INVENTION]

As explained above, an LCD device according to the principles of the present invention has advantages of conventional TN-LCD and IPS-LCD devices, including a low dependence of color on the viewing angle, a high aperture ratio, and a wide viewing angle. In addition, since the FLCP layer of its upper orientation film changes alignment so fast, an LCD device according to the principles of the present invention shows superior response.

[RANGE OF CLAIMS]

[CLAIM 1]

A liquid crystal display device comprising:

first and second substrates facing to and spaced apart from each other;

first and second electrodes formed on inner surfaces of the first and second substrates, respectively;

a first orientation film on the first electrode, the first orientation film including a ferroelectric liquid crystal polymer;

a second orientation film on the second substrate;

first and second polarizers on exterior surfaces of the first and second substrates; and

a liquid crystal layer between the first and second orientation films.

[CLAIM 2]

The device of claim 1, wherein the second orientation film includes a homogeneous alignment film.

[CLAIM 3]

The device of claim 1, wherein said first polarizer has a polarization axis perpendicular to an alignment direction of said first orientation film.

[CLAIM 4]

The device of claim 1, wherein said second polarizer has a polarizing axis parallel to an alignment direction of said second orientation film.

[DOCUMENT OF ABSTRACT]

[ABSTRACT]

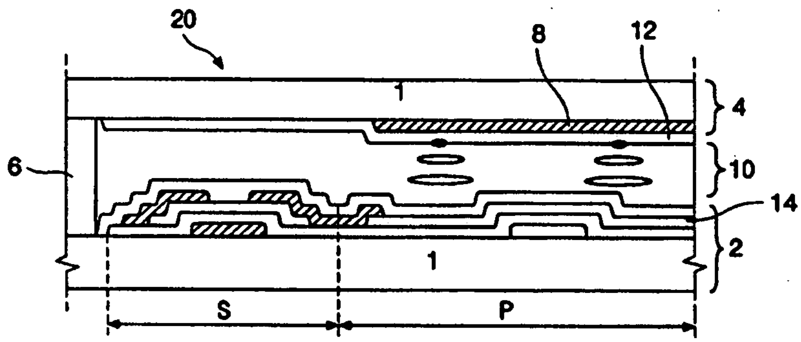
A liquid crystal display device includes first and second substrates spaced apart from each other. First and second electrodes are formed on opposing surfaces of the first and second substrates, respectively. A first orientation film of a ferroelectric liquid crystal polymer is formed on the first electrode, and a second orientation film is formed on the second electrode. First and second polarizers are formed on the exterior surfaces of the first and second substrates, respectively. The liquid crystal display device further includes a liquid crystal layer interposed between the first and second orientation films. The liquid crystal display device of the present invention has a improved aperture ratio and a wider viewing angle.

[REPRESENTATIVE FIGURE]

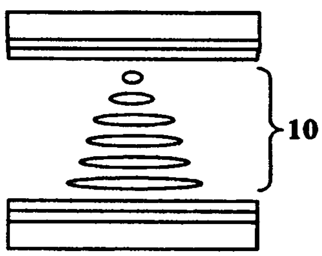
FIG. 8

[DRAWINGS]

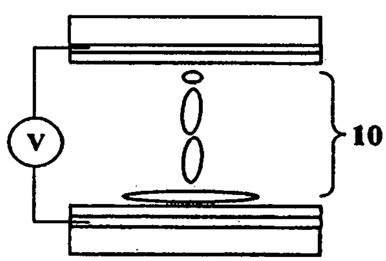
[Fig. 1]



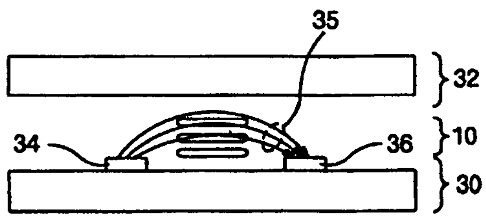
[Fig. 2 A]



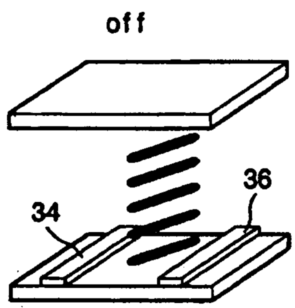
[Fig. 2B]



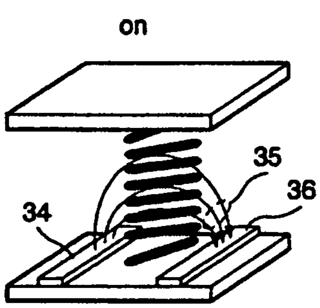
[Fig. 3]



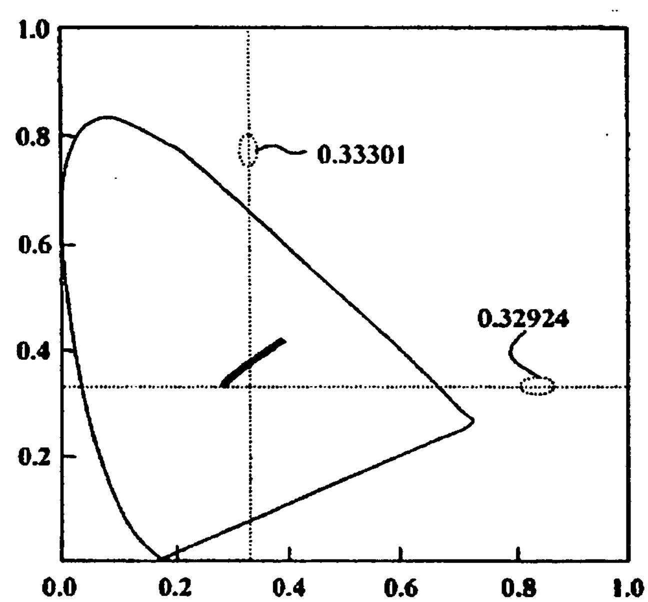
[Fig. 4A]



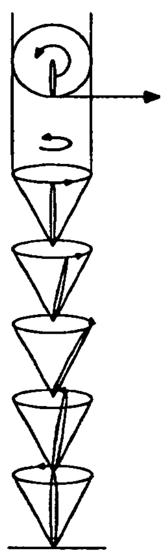
[Fig. 4B]



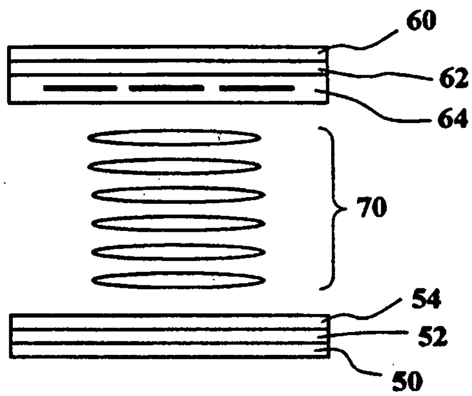
[Fig. 5]



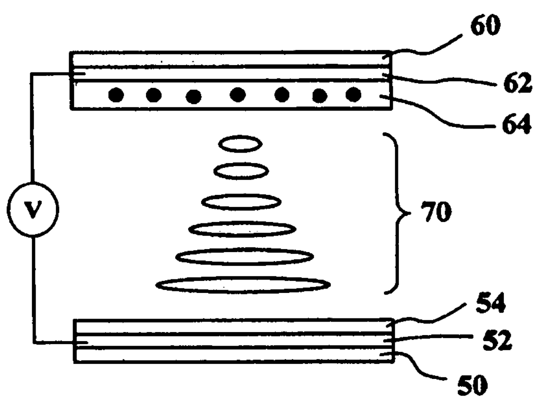
[Fig. 6]



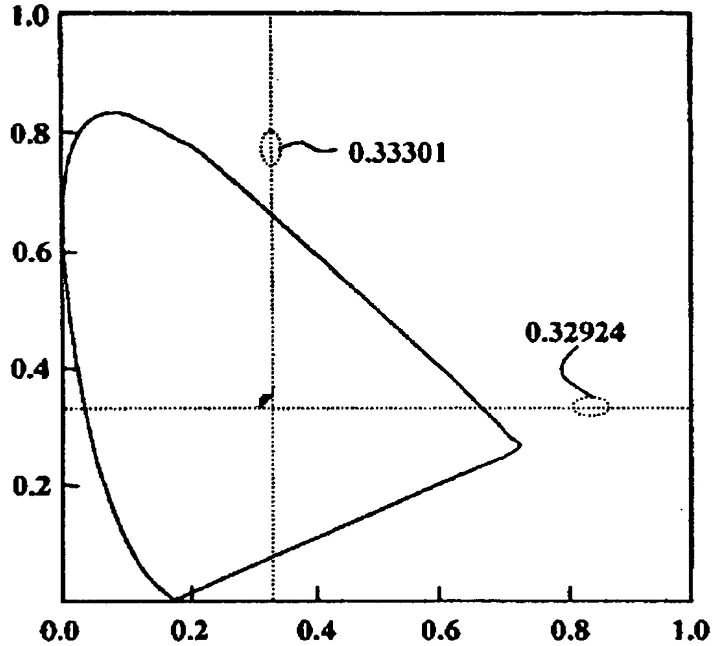
[Fig. 7]



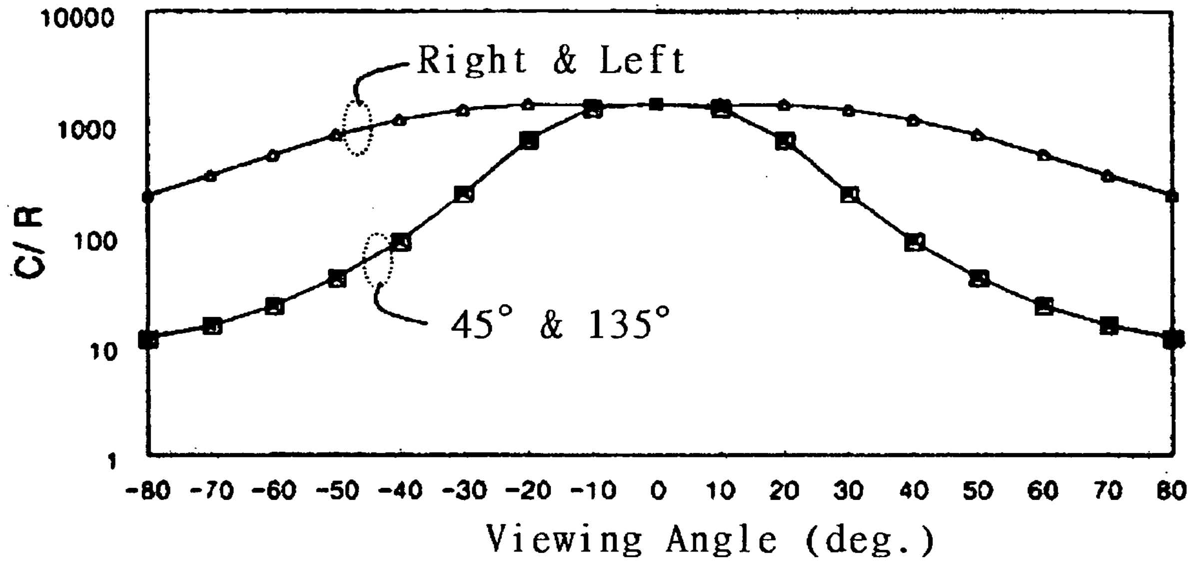
[Fig. 8]



[Fig. 9]



[Fig. 10A]



[Fig. 10B]